Equilibrium → particle (2-D)
→ particle (3-D)

⇒ Equilibrium of Rigid body

1-) 2-D

1) Definition of R.B & Description of problem

R.B → Body has dimensions → شغلة

and the forces, free couples are distributed on the body (Not connected at one point)

2) Equation = Rules

Types of motion

3-types of motion { along x-dir → translation
along y-dir → translation
Rotation

1) $\Sigma F_x = 0$ prevent x motion

2) $\Sigma F_y = 0$ No motion along y

3) ΣM all forces + free couples $= 0$ No Rotation
@ any point

3) Types of unknowns

3-1) Tension inside cables or cords and forces in rods

⇒ In rods assume Internal force as Tension (T)

B

cable

A

Rod

3-2) Reactions at external supports

Supports device to prevent motion by reaction

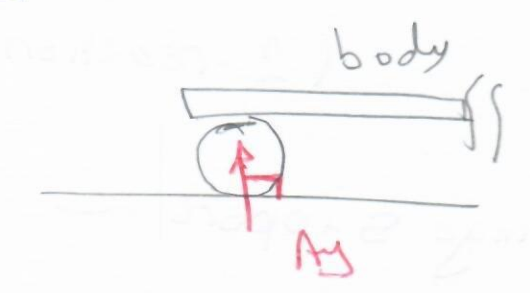
3-2-1 Support prevents one-motion (one-reaction) (one unknown)

* Smooth contact surface

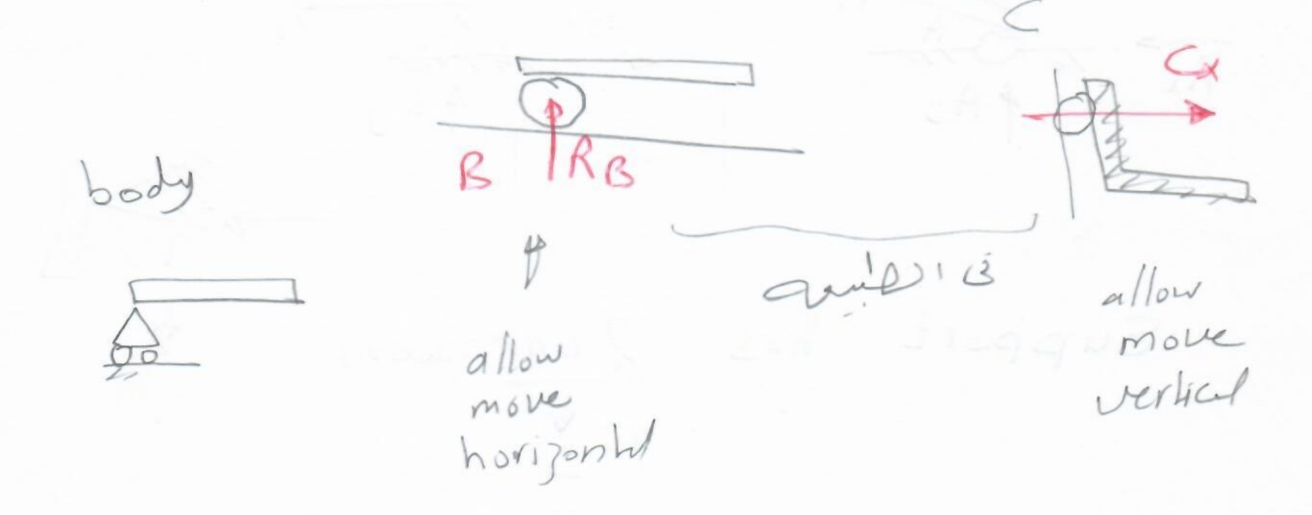
smooth

Rc

* Rocker support



* Rollar support



$R_c \sin\theta$

θ

R_c — one unknown

$R_c \cos\theta$

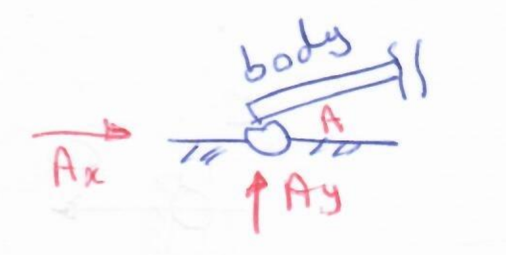
Support has one unkown

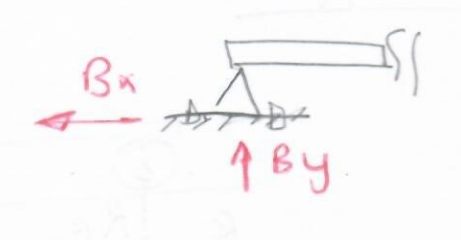
⊥ plane of sliding

3-2-2 Support prevents 2.motions

(2-reactions - 2unknown)

hinge support ~ pin support



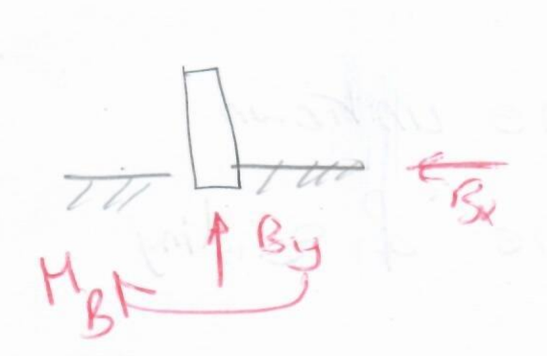


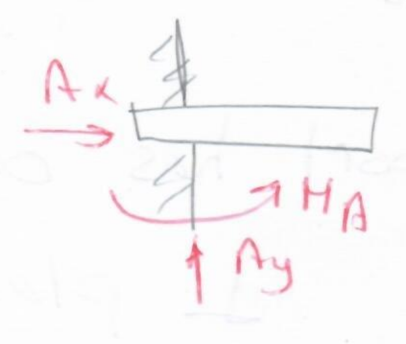
Support has 2 unknowns
↓
x, y

3-2-3 Support prevent All motions

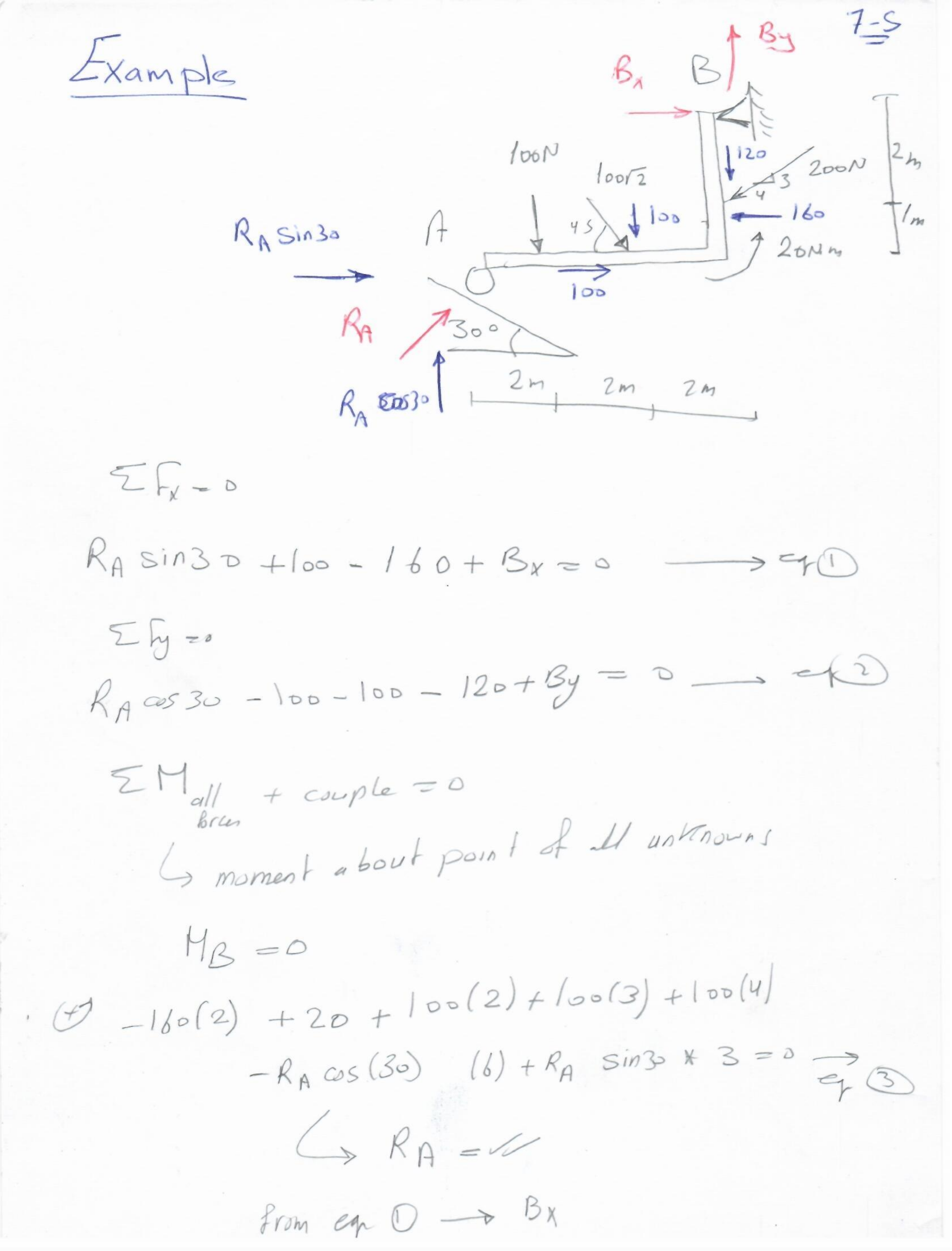
(3-reaction ~ 3 unknowns)

Fixed support





⟹ 3 unknowns x, y, couple (M)



Example

$\Sigma F_x = 0$

$R_A \sin 30 + 100 - 160 + B_x = 0 \longrightarrow$ eq ①

$\Sigma F_y = 0$

$R_A \cos 30 - 100 - 100 - 120 + B_y = 0 \longrightarrow$ eq ②

$\Sigma M_{\substack{all \\ forces}} + \text{couple} = 0$

↳ moment about point of all unknowns

$M_B = 0$

(+) $-160(2) + 20 + 100(2) + 100(3) + 100(4)$

$- R_A \cos(30) \ (6) + R_A \sin 30 * 3 = 0 \longrightarrow$ eq ③

↳ $R_A = \checkmark$

from eq ① $\longrightarrow B_x$

Example 1

Find reactions at C

300 N, 200 N, 400 N, 0.3m, 0.4m, 0.2m, 200N, 0.7m, 60N.m, X_C, Y_C, M_C

$\rightarrow R_x = X_C - 200N = 0$

$x_C = 200N$

$\rightarrow R_y = Y_C - 300 - 200 - 400 = 0$

$Y_C = 900N$

$\rightarrow \Sigma M_C = 0 \quad M_C + 60 + 200 * 0.7 + 200 * 0.4 + 300 * 0.7 = 0$

$M_C = -390 N.m$

Example 3

Find Reactions

375N, 250mm, 250mm, D, C, N_B, 60°, 300mm, A, X_A, Y_A, y, x

$\Sigma F_x = R_x = 0$

$X_A - N_B \sin 60 = 0 \rightarrow (1)$

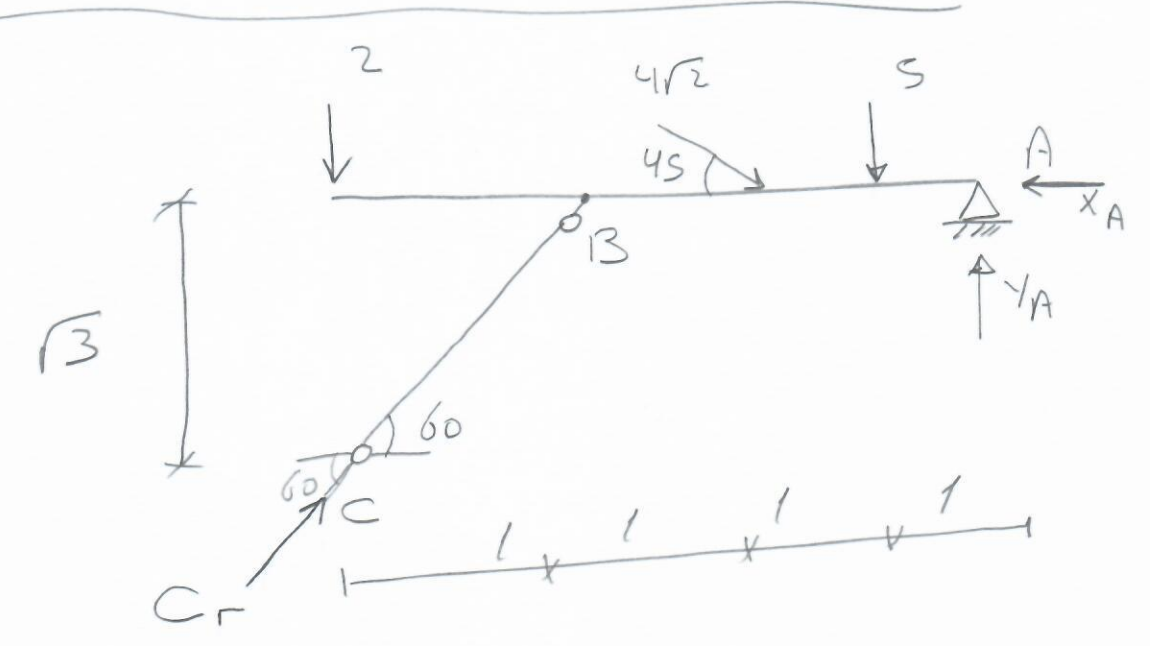
$R_y = 0$

$Y_A + N_B \cos 60 - 375 = 0 \rightarrow (2)$

$\Sigma M_A = 0 \quad + \circlearrowleft \; -375 * 0.25 + 0.3 * N_B \sin 60 + 0.5 N_B \cos 60 =$

$-93.75 + 0.509 N_B = 0 \rightarrow N_B = 183.89$

Example for Link member (2-force member)



$\rightarrow \Sigma F_x = 0$

$C_r \cos 60 - X_A + 4\sqrt{2} * \cos 45 = 0$

$\frac{1}{2} C_r - X_A = -4 \longrightarrow$ (1)

$\uparrow \Sigma F_y = 0$

$C_r \sin 60 - 2 - 4\sqrt{2} \sin 45 - 5 + Y_A = 0$

$\frac{\sqrt{3}}{2} C_r + Y_A = 11 \longrightarrow$ (2)

$\circlearrowleft + \Sigma M_A = 0$

$-C_r \cos 60 * \sqrt{3} + C_r \sin 60 * 4 - 2*4 - 4*2 - 5*1 = 0$

$C_r = \frac{14\sqrt{3}}{3} = 8.08 N$

$\therefore X_A = 8.041 N$